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The Vitamin Needs of Farm Animals

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THE VITAMIN NEEDS OF FARM ANIMALS

INTRODUCTION

What are vitamins?—Vitamins are necessary organic food substances distinct from the proteins, fats, carbohydrates, and minerals—the more familiar components of feeds. Although present in feeds in small quantities, the vitamins are vital for proper and economical performance. Because for a long time the chemical identity of not a single vitamin was known, various letters of the alphabet were applied to these substances whose functions in the body could be determined but whose chemical designation remained unknown. This led to the popular belief that vitamins were mysterious things not to be taken too seriously. Present knowledge has reached the point where the chemical composition of several of the vitamins is known and chemical names have been assigned them to replace the letters previously used. Vitamin C, for example, is now known to be ascorbic acid, a definite organic compound. Vitamin B now becomes thiamin chloride; vitamin G, riboflavin; and vitamin P-P, nicotinic acid. These vitamins have not only been identified—they have been made in the laboratory.

How many vitamins are there?—Rather conclusive evidence has been presented as to the existence of eight distinct vitamins. These are listed in the first column of Chart 1. Other evidence is constantly accumulating which suggests that the present vitamin list is by no means complete.

What are the functions of the vitamins?—A deficiency of any one vitamin leads to definite symptoms in a proper experimental animal. Once it had been determined what type of ration produced repeatedly the same symptoms, details of the steps that resulted in the final deficiency picture were worked out. Thus the functions of the vitamins became known. These functions have been studied in greater detail with some vitamins than with others. Some of the functions of the various vitamins are listed in Chart 1.

The end result of a vitamin depletion is usually striking, but not always apparent to the eye. In the case of vitamin E, for example, long before sterility results in those species which require vitamin E, cellular changes which produce no external symptoms may be taking place. Also, when animals fail to show the classical opthalmia (sore eyes) of vitamin A deficiency there is no assurance that a vitamin A deficiency does not exist. In column 3 of Chart 1 some of the symptoms to be looked for when vitamin deficiencies exist are listed.

Where are the vitamins found?—The vitamins are widely distributed in plant and animal materials that are commonly fed to livestock and poultry. In Chart 2 the relative vitamin content of most of the common livestock and poultry feeds is listed. Because of lack of sufficient data, only vitamins A, B, C, D, E, and G are used in this classification.

Analysis of this chart points out the important role played by good roughage in furnishing the various vitamins. It shows also that green feeds, legume silage, and unbleached hay are the principal sources of vitamins A and G; that all grains except yellow corn and by-products made from it have practically no vitamin A activity but are good sources of vitamin B; that vitamin E seems to be concentrated in the germ; and that practically all feeds are either devoid of or poor to fair sources of vitamin D. This lack of vitamin D in farm feeds is overcome by making maximum use of direct sunlight and sun-cured hay, and by using, when needed, concentrated sources of this vitamin.

CHART 1.—Vitamins: Their Functions and Symptoms of Deficiency

Name	Functions	Results of deficiency or absence
Vitamin A (colorless form) Carotene (orange-colored pigment)	Promotes growth Protects epithelial and nerve tissues Protects against respiratory infections Essential for normal reproduction and lactation	Opthalmia (sore eyes) Stunted growth Impaired vision; night blindness Scours and pneumonia Kidney and bladder stones Nerve degeneration Lowered resistance to infections
Vitamin B (thiamin chloride)	Stimulates appetite and digestion Promotes growth Protects against nerve diseases Essential for normal reproduction and lactation	Polyneuritis Paralysis Poor appetite Impaired growth Decreased fertility
Vitamin C (ascorbic acid)	Necessary for normal activity of body cells Essential for normal bone and tooth development Maintains capillary resistance	Scurvy Muscular pains and weakness Hemorrhages throughout body Fragile bones Loosening and decay of teeth
Vitamin D	Regulates utilization of calcium and phosphorus	Rickets Soft and weak bones Enlarged joints Stiffness
Vitamin E	Essential for normal reproduction	Sterility Disturbance of reproductive functions in males and females Death of developing young
Vitamin G (riboflavin)	Promotes growth Necessary for embryonic development (birds)	Stunted growth Leg disorder in chicks Decreased egg production and hatchability
Vitamin K	Maintains normal clotting time of blood Possibly maintains capillary resistance	Internal and tissue hemorrhages
Vitamin P–P (nicotinic acid)	Prevents pellagra in humans and black-tongue in dogs	Pellagra (humans) Blacktongue (dogs) Digestive disturbances (diarrhea)

Although it is possible in the laboratory to determine the vitamin potency of given feeds in terms of international standards, the use of definite figures has been avoided in Chart 2 because of the variations in potency that may exist owing to factors such as species of plant, stage of maturity, method of curing, length of storage, method of manufacture, and the like.

Vitamin A exists in two forms. One is colorless (true vitamin A), and the other an orange-colored pigment, carotene (provitamin A). The colorless form occurs in fish oils and in animal materials; the colored form also is found in animal materials but is the only form found in plants. When carotene-containing feeds are consumed, varying quantities of carotene are converted into vitamin A in the liver. The degree of this conversion depends upon the species and breed. The amount of carotene in plant materials can be determined chemically and values so obtained can be converted into biological units of true vitamin A. Either the colored or colorless form can serve as a source of vitamin A.

CHART 2.—Vitamin Content of Feeds*

Feeds	Vitamins					
	A	B	C	D	E	G
Roughages:						
Legume hay, choice (leafy and green)	3+	1+	0	1+	3+	2+
Legume hay, poor (leached and bleached)	0 to 1+	1+	0	1+	0 to 1+	1+
Legume hay, dehydrated	4+	1+	0	0	3+	3+
Timothy hay, choice	1+ to 2+	1+	0	1+	2+	2+
Timothy hay, poor	0 to 1+	1+	0	1+	0 to 1+	0 to 1+
Corn fodder	0 to 1+	1+	0	1+	—	—
Straw	0	—	0	—	—	—
Succulent pasture	4+	1+	3+	0	3+	2+
Legume silage	2+ to 3+	1+	2+	0	—	0 to 1+
Corn silage	1+ to 2+	1+	2+	0 to 1+	1+	0 to 1+
Roots, vegetables, and the like:						
Beets	0	0	1+	0	—	—
Beet pulp, dried	0	0	0	0	—	—
Cabbage, green leaves	2+	1+	3+	0	—	1+
Cabbage, white portion	1+	1+	3+	0	—	—
Carrots, yellow	3+	1+	2+	0	—	—
Kale, green	3+	1+	3+	0	—	—
Mangels	0	0	0	0	—	—
Potatoes	0	1+	2+	0	—	—
Rutabagas	0 to 1+	1+	3+	0	—	—
Sweet potatoes, yellow	2+	1+	2+	0	—	—
Grains:						
Barley	0	2+	0	0	2+	1+
Buckwheat	0	2+	0	0	—	1+
Corn, white	0	3+	0	0	2+	1+
Corn, yellow	2+	3+	0	0	2+	1+
Oats	0	2+	0	0	2+	1+
Soybeans	0	2+	0	0	—	1+
Wheat	0	3+	0	0	2+	1+
Grain by-products:						
Corn gluten meal, yellow	3+	—	0	0	0	0
Cottonseed meal	0	2+	0	0	1+ to 2+	1+
Hominy feed, yellow	2+	3+	0	0	2+	1+
Hominy feed, white	0	3+	0	0	2+	1+
Linseed meal	0	2+	0	0	1+ to 2+	1+
Soybean oil meal	0	2+	0	0	1+ to 2+	1+
Wheat bran	0	2+	0	0	2+	1+
Wheat germ	0	4+	0	0	4+	2+
Wheat middlings	0	3+	0	0	3+	1+
Milk and milk products:						
Buttermilk	1+	1+	0 to 1+	0	1+	2+
Buttermilk, dried	1+	1+	0 to 1+	0	1+	3+
Skimmilk	0	1+	0 to 1+	0	1+	2+
Skimmilk, dried	0	1+	0 to 1+	0	1+	3+
Whey, dried	0	1+	0 to 1+	0	1+	3+
Whole milk	2+ to 3+	1+	1+	1+	1+	2+
Animal by-products:						
Fish oils	4+	0	0	4+	0	0
Fish meal	0 to 1+	0	0	0 to 1+	—	0 to 2+
Meat scraps	0	0	0	0	—	1+
Tankage	0	0	0	0	—	1+
Miscellaneous materials:						
Eggs	2+	1+	0	2+	2+	3+
Liver, dried	2+	1+	1+	1+	—	4+
Molasses, cane	0	2+	0	0	2+	0
Sunlight, direct	0	0	0	4+	0	0
Yeast, dried	0	4+	0	0	0	3+

* 0 indicates that the feed has none or practically none of the vitamin.
1+ indicates that the feed is a poor source.
2+ indicates that the feed is a fair source.
3+ indicates that the feed is a good source.
4+ indicates that the feed is an excellent source.
— indicates lack of information.

THE VITAMIN PROBLEM IN FARM FEEDING

DAIRY CATTLE

Vitamin A.—This vitamin is very important in dairy cattle feeding. It is required by animals of all ages and is particularly essential in rapidly growing young animals and in pregnant cows during the last few months of gestation.

According to the United States Bureau of Dairying, calves require the equivalent of about 15 milligrams of carotene daily. This amount of vitamin A activity can be supplied in 3 to 4 teaspoonfuls of cod-liver oil or 2 to 3 pounds of legume hay of average quality. Newly born calves should receive colostrum and then whole milk for several weeks to satisfy their vitamin A requirements until the time when hay and a grain mixture containing yellow corn are fed. Even when whole milk is fed, insufficient vitamin A intake may result if the cows producing the milk have been fed poor roughage for a long period.

Stunted growth, scours followed by pneumonia, and night blindness are symptoms of vitamin A deficiency in calves.

In growing heifers the vitamin A requirement is proportional to body weight, about 1.25 milligrams of carotene daily for every 100 pounds. This amount is contained in about ⅕ pound of average legume hay per 100 pounds of live weight.

A pregnant heifer or cow has a much higher requirement, particularly during the last 3 months of gestation. The carotene requirement at this time is approximately 90 milligrams daily. To meet this requirement, it takes from 15 to 20 pounds of average legume hay or 7 to 8 pounds of hay and 15 to 20 pounds of corn silage. Legume silage of high quality usually is a good source of carotene, containing in 10 pounds enough to meet the requirement of a dry, pregnant animal. A dead, weak, or blind calf may be the first symptom of inadequate vitamin A intake during pregnancy.

Unless it is desired to market milk on the basis of depth of yellow color, the requirement of vitamin A for milk production should be met by the same system of feeding that allows normal reproduction. The yellow color in milk can be increased by raising the cow's intake of carotene-rich feeds, such as pasture, legume silage, and carrots.

Recent evidence shows that low vitamin A intake may seriously affect the reproductive organs and functions of males. On this basis alone the practice of feeding dairy bulls "bull hay" or any kind of roughage that happens to be left over should be discouraged. The bull should receive not less than 5 pounds of good quality legume hay or its equivalent daily.

Under most practical conditions, no serious effects from low vitamin A intake should be experienced so long as maximum use is made of good pasture. Cattle store vitamin A in their livers when their intake is high and can use this later when the intake is low. When hay of poor quality has been fed during the winter as the only roughage or along with other poor roughage, such as corn fodder, the purchase of some good quality hay in late winter may prove to be a good investment.

Vitamin D.—The vitamin D requirements of dairy cattle have not been extensively studied, although it is known that vitamin D is needed by dairy animals of all ages. For ordinary purposes, the requirement is apparently low and can be met by exposing the animals to direct sunlight as much as possible and by feeding sun-cured hay.

Under even the best feeding conditions, cow's milk is low in vitamin D. To produce milk containing enough vitamin D to be classified as "vitamin D milk", special feeding must be resorted to.

Vitamin E.—Vitamin E is so widely distributed in both roughages and concentrates that it is difficult to conceive of dairy animals or other farm herbivora suffering from vitamin E deficiency when good feeding practices are used. No conclusive evidence has been presented to the effect that dairy cattle or other farm herbivora require vitamin E in their feed. If recent work with goats, done at Iowa State College, can be used as a guide, they probably do not.

Vitamin C.—Dairy cattle and other farm animals apparently are able to manufacture vitamin C and therefore do not require it in their feed.

Vitamins B and G.—Nothing definite is known regarding the requirement of dairy cattle or other farm herbivora for these two vitamins, although early work done before the "vitamin B complex" had been separated into B and G has been interpreted to mean that the members of the B complex are not needed in the feed. Further definite proof of this is needed. Meanwhile no concern over meeting the requirements for vitamins B and G need be felt because of the rather generous amounts that are present in grains and in good quality roughage.

Vitamins K and P-P.—Nothing is known regarding the requirements of dairy cattle or other farm herbivora for these vitamins.

BEEF CATTLE

Vitamin A.—So far as is known, the only vitamin that is of practical importance in feeding beef cattle under usual conditions is vitamin A. Although we have only meager information on the quantitative requirements of vitamin A by beef cattle, from experimental and practical observation it appears that their vitamin A needs will be met when they are on green pasture or when they are fed a reasonable amount of well-cured legume hay. Good silage will also provide sufficient of this vitamin, under most conditions. Vitamin A may become a limiting factor when beef cattle receive poor roughages, such as straw, hay of poor quality, and cottonseed hulls, or are forced to subsist for long periods on dry, weathered grass that follows periods of long drouth.

Feeding a limited amount of well-cured legume hay or roughage rich in vitamin A value (carotene) will insure against a vitamin A deficiency. Beef cattle receiving a good quality roughage (high in carotene content) will do as well on white corn as on yellow corn. If the roughage is of poor quality (low in carotene), yellow corn is superior to white corn.

Vitamin D.—The needs of beef cattle for this factor can be met by giving the animals access to direct sunshine as much as possible and by feeding sun-cured hay.

Vitamins E, C, B, G, and other factors.—Refer to discussion under dairy cattle.

SHEEP

Vitamin A.—This is probably the only vitamin that may be deficient in the usual method of feeding sheep. The practical vitamin A needs of sheep have not been extensively investigated. It appears that the needs of sheep will be met when they are on green pasture or are fed liberal amounts of early cut well-cured hay or other roughage high in vitamin A value (carotene content). A deficiency is likely to occur if they are forced to subsist for a long period on dry,

weathered pasture or are fed poor quality roughages, such as cereal straw, poor quality hay, cottonseed hulls, and corn fodder. A lack of vitamin A can be guarded against by the use of high-quality roughages and green pasture.

Vitamin D.—Sheep require vitamin D. Because they are generally outdoors and exposed to direct sunlight much of the time, they are usually protected against a vitamin D deficiency. Sun-cured hays will also provide additional vitamin D.

For the other vitamins, refer to the dairy cattle section.

SWINE

Vitamin A.—This vitamin is important in profitable pork production. Its deficiency is characterized by impaired vision, a staggering gait, and a general lack of muscular coordination. In severe cases, both vitamin A and vitamin D deficiencies produce difficulty in walking. The difficulty resulting from vitamin A deficiency is brought about by a degeneration of the nervous system and that from vitamin D deficiency, rickets, by soft or broken bones.

Mill feeds, grain by-products, and grains other than yellow corn do not supply significant amounts of vitamin A. Tankage, meat scraps, skimmed milk, buttermilk, and whey are likewise deficient in vitamin A. Inasmuch as its content is influenced by its origin and by the process of manufacture, fish meal is not a dependable source of vitamin A.

The amount of vitamin A required by swine is not definitely known. Since green feeds supply an ample amount, hogs should be provided with good pasture for as much of the year as possible. If yellow corn is fed as the grain, there is probably no serious shortage of vitamin A in the ration for growing and fattening pigs, even when they are not on pasture. For feeding under dry lot conditions, however, from 3 to 5 per cent of excellent quality legume hay or meal in the ration will help to insure against a possible vitamin A deficiency. Under such conditions, unless yellow corn is fed, the use of hay or other material supplying vitamin A is imperative.

Fattening shotes that have been grown on good pasture may have a sufficient storage of vitamin A to enable them to make satisfactory gains up to usual market weights, even when fed rations containing no hay and only a limited amount of yellow corn.

To ensure that brood sows receive adequate vitamin A, their ration, when they are not on pasture, should contain 10 to 15 per cent of good quality legume hay even though yellow corn is fed. The hay can be fed in racks or be ground and mixed with the other feed.

Vitamin D.—Although there is little information on the amount required, the need for vitamin D by swine has been demonstrated. Rickets perhaps is more prevalent in pigs than is any other deficiency disease. A lack of vitamin D results in rickets and reproductive failures.

None of the mill feeds, grains, grain by-products, or protein concentrates supply appreciable amounts of vitamin D. Fish meal sometimes apparently provides this vitamin but cannot be relied upon as a dependable source unless one is certain of the method and the material used in its manufacture.

Regardless of whether they have pasture, exposure to direct sunlight in summer will protect swine against a deficiency of vitamin D. During the winter, in northern states, swine are apt to suffer from a lack of vitamin D unless some material furnishing it is included in the ration. This is especially true of young, rapidly growing pigs.

Sun-cured legume hay is a good practical source of vitamin D, and the inclusion of 3 to 5 per cent or more in a good ration will meet the needs of the animal for this vitamin. If sun-cured legume hay or meal of good quality is not available, it is advisable to include 0.125 to 0.25 per cent of cod-liver oil concentrate or 0.5 to 1.0 per cent of cod- or similar fish liver oil in the ration.

Vitamin E.—Although it is reasonable to suppose that swine require vitamin E, no conclusive evidence has been presented to the effect that this vitamin may be a limiting factor when good practical rations are used. Grains, grain by-products, and high-quality roughages are good sources of vitamin E and, since the ration of swine usually includes liberal amounts of these feeds, it is difficult to conceive of a deficiency of vitamin E.

Vitamin C.—Swine either do not require this vitamin in their feed or are able to manufacture it in their bodies.

Vitamins B and G.—Both these vitamins are required by swine. The usual rations which include grains, grain by-products, animal protein concentrates, high-quality legume hay or meal or green forage will supply the needs for growth and reproduction. No experimental evidence has been presented which indicates that additional amounts of vitamins B and G need be added to a good ration.

Vitamins K and P-P.—Nothing is known regarding the needs of swine for vitamin K. Because this factor is present in large amounts in good quality legume hay and is also found in green forage and meat by-products, it would appear that all practical needs would be satisfied if swine required it.

Recent experimental work indicates that swine require the P-P factor (nicotinic acid). Its deficiency in the experimental ration results in loss of appetite, stunted growth, and intestinal disturbances (diarrhea). Further work is needed before it can be determined whether a deficiency of this factor might occur under good swine feeding and management practices.

POULTRY

Vitamin A.—This vitamin is required by birds of all ages. A lack of vitamin A results in poor growth, an unsteady gait, and high mortality in chicks, and in decreased egg production, lowered hatchability, and nutritional roup in older birds.

Careful experimental work has shown that chick rations should contain at least 1500 units of vitamin A per pound of total feed in order that the pullets may enter the productive period with adequate reserves of this vitamin. Laying birds have a somewhat higher requirement. Recent work has shown that the total ration of the laying bird should contain not less than 2200 units of vitamin A per pound to maintain them in good health and to produce eggs that will hatch well.

The common sources of vitamin A for poultry are yellow corn, high-quality legume meals, and green forage. Birds that are on green range receive adequate vitamin A from the grass or forage they eat. When they are confined or have access to a bare yard, vitamin A will become a limiting factor unless yellow corn and a high-quality legume meal or a vitamin A – potent fish oil is used in the ration. The vitamin A requirements of chicks and hens are met if 50 per cent of the total ration consists of yellow corn and 5 per cent or more of a good quality (high carotene), green-colored alfalfa meal.

Vitamin D.—This is perhaps the most important vitamin to be considered in feeding poultry, because it is lacking in most of the common poultry feeds. A deficiency of this factor causes rickets (leg weakness), poor hatchability, low egg production, and thin-shelled eggs.

A sufficient exposure of poultry to direct sunshine will meet their vitamin D requirements. However, when poultry are confined for long periods of time some source of vitamin D must be included in their feed.

Careful experimental work has shown that the ration of chicks should contain approximately 175 A. O. A. C. chick units of vitamin D per pound of total ration. Laying birds have a higher requirement than growing chicks. Studies on the needs of laying birds have shown that their ration should contain not less than 300 A. O. A. C. chick units per pound of total feed for good egg production and hatchability.

The most practical way of supplying vitamin D, when direct sunlight is not available, is to use a biologically tested fish oil or fish oil concentrate. The amount of oil to add to supply the above unitage depends upon the vitamin potency of the oil supplement.

Vitamin E.—The hen is one of the few animals which has been shown to require this vitamin for reproduction. There is, however, no experimental evidence which shows conclusively that good poultry rations are lacking in this vitamin. This is not surprising, because vitamin E is found in grains, wheat by-products, and green plant tissues, which normally constitute a large part of the poultry ration.

Vitamin C.—Poultry have subsisted on rations containing no vitamin C for long periods of time without noticeably harmful effects. Presumably this species, as others, can synthesize this vitamin.

Vitamin B.—A deficiency of this factor causes polyneuritis. Recent work has shown that a ration which contains 100 to 115 International units of vitamin B per pound will protect a chick against polyneuritis. A good poultry ration which consists of approximately 75 per cent or more of whole or ground grains and wheat by-products will contain about three times the above necessary unitage of vitamin B to protect the chicks against the development of polyneuritis. It therefore appears that the usual poultry ration will supply ample vitamin B.

Vitamin G (riboflavin).—Poultry require this factor for satisfactory growth, egg production, and hatchability. Recently it has also been found that nutritional leg weakness (curly toe paralysis) is prevented by feeding chicks adequate amounts of vitamin G (riboflavin).

According to studies made at Cornell University, the vitamin G or riboflavin requirements of chicks during the first 8 weeks of life are approximately 1300 chick units per pound of total feed. Breeders require about 1050 chick units per pound of total feed to produce eggs that hatch normally.

The chief sources of vitamin G (riboflavin) for poultry are milk by-products, high-quality alfalfa meals, and succulent green feed. Pure dried yeast and dried liver are also good sources of this factor. Birds having free access to young, tender grass will be provided with adequate vitamin G for growth and egg production. For starting chicks and for maximum hatchability, 5 per cent or more of a milk product or its equivalent should be included in the ration even though the birds have access to green forage. When chicks or layers are confined indoors, their ration should contain not less than 5 per cent of a milk product or its equivalent and 5 per cent of a high-quality legume meal in order to insure against an inadequate intake of vitamin G (riboflavin).

Vitamins K and P-P.—Vitamin K is required by poultry to maintain the normal clotting power of the blood. In the absence of this factor chicks bleed to death from any injury which causes a rupture of the blood vessels. A lack of vitamin K seldom occurs, because common feedstuffs, particularly high-quality alfalfa meal, adequately provide this vitamin.

No information is available concerning the P-P factor (nicotinic acid) requirements of poultry. It is highly questionable whether practical poultry rations are lacking in this factor.

Chick antidermatosis factor.—In recent years it has been shown that chicks apparently have need for a vitamin-like factor which prevents the development of granulations about the eye and at the corners of the mouth and a cracking or the appearance of fissures on the bottom of the toes. Facts concerning this factor are still in the experimental stage. It is questionable whether this factor will be of practical importance in poultry rations, especially if sufficient milk and alfalfa are used in the feed to make it adequate in riboflavin.

Vitamin B_4 (anti-encephalomalacia factor).—The requirements of poultry for this factor have not yet been studied in a quantitative manner. There are indications that the disorder commonly referred to as the "crazy chick disease", which sporadically occurs in practice, may be related to a deficiency of vitamin B_4. Further investigations are required before any definite statements concerning practical poultry rations and needs for this factor can be made.

The first principle of avoiding vitamin deficiencies in livestock and poultry feeding involves maximum use of high-quality roughages and direct sunlight. High-quality roughages include pasture, legume or grass silage, corn silage, sun-cured legume hay that is leafy and green, timothy and timothy mixtures that are cut early and cured so as to retain their green color, and artificially dehydrated hay. Such a system of feeding with animals that normally consume large quantities of roughage will make it unnecessary to purchase special vitamin preparations.

In animals that consume relatively little roughage in proportion to concentrates (swine and poultry), maximum use of green pasture and range, or high-quality legume hays and meals, and direct sunlight, will take care of the vitamin needs under most conditions. When chickens are kept in confinement, liberal use should be made of milk products and high-quality legume meal. The most practical way to supply vitamin D to confined birds is to use some biologically tested fish oil or its equivalent.